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Effect of Soft Storey on Multi-storey Building

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***Abstract:** In the present work study is carried out for the behavior of G + 10 storied RC buildings with Rectangular shaped plan of soft storey at different levels. Floor height provided as 3.4m and also properties are defined for the irregular R.C building modelled in STAAD. Pro V8i software. Here twelve models are created in which soft storey is provided at ground, fifth and eleventh storey in all four seismic zones. From result it is found that Location of Soft storey effects seismic behavior of building in every zone from low to high seismicity. As the location of soft storey goes upper it gives more stable structure compared to soft storey at ground level. Soft storey at top level of structure is more stable than soft storey at middle part of structure, soft storey at top level gives Lower values of displacement in all seismic zones.*
***Keywords:** STAAD pro., seismic zones, base shear, overturning moment, displacement, soft storey*

I. INTRODUCTION

Many buildings structure having parking or commercial areas in their first stories, suffered major structural damages and collapsed in the recent earthquakes. Large open areas with less infill and exterior walls and higher floor levels at the ground level result in soft stories and hence damage. In such buildings, the stiffness of the lateral load resisting systems at those stories is quite less than the stories above or below. During an earthquake, if abnormal inter- story drifts between adjacent stories occur, the lateral forces cannot be well distributed along the height of the structure. A simple understanding of soft storey is sudden change of lateral storey stiffness within the structure. An irregularity in vertical configuration tends to create sudden changes in strength or stiffness that may concentrate earthquake forces or other forces in an undesirable way. These can be very difficult to deal with even in a modern structure although the size of the overall force that building must withstand is determined by the Newton's second law of motion, the way in which this is distributed and concentrated, is determined by the configuration of building in horizontal and vertical direction. The overall forces are concentrated at one or few points of the buildings such as a particular set of beams, columns, or walls. These few members may fail and, by chain reaction, bring down the whole building. The most serious condition of vertical irregularity is that of the soft storey.

II. LITERATURE REVIEW

Pravesh Gairola - 2019 In this paper an investigation has been made to study the seismic behavior of soft storey building with different models (Bare frame, Infill frame, Bracing Frame, Shear wall frame) in soft storey building when subjected to earthquake loading. It is observed that, providing different models improves resistant behavior of the structure when compared to soft storey provided.

Ghalimath. A. G-2016 In this case study R.C.C.plane frame building is modelled and analysed in two cases. I) Model with no infill wall (Bare Model) with foundation depth=1.5 m.

II) Model with no infill wall (Bare Model) with foundation depth 3.5 m (soft storey). Static analysis of the building models is performed in ETABS. The performance of the building is evaluated in terms of top storey displacement, natural period, base shear, shear forces and bending moment in beams, axial forces and bending moment in column. It is found that axial forces and bending moment in corner as well as end column increases in parking storey and increases the top storey displacement in parking building.

Akhilesh Yadav 2017 In the design offices engineer experienced that the multiplication factor 2.5 is not realistic for the open ground storey low rise building and required critical assessment of the multiplication factor for open ground storey building. Therefore, in this thesis the objective is to assess the effect of infill wall, check the multiplication factor and effect of support condition of the building. In this analysis, the multiplication factor 2.5 is seen that too high for the open ground storey low rise building. the problem the problem of open ground storey low rise building cannot be properly identified through the elastic analysis as the stiffness of open ground storey building and similar bare frame is same. According to the nonlinear analysis of the OGS low rise building fails through the soft storey mechanism at a comparatively low base shear and displacement and the mode of failure is found to be brittle. In this analysis shows that the support condition of the building influences the considerable and important parameter for the multiplication factor.

Jamdar Ameerhusain S - 2020 In the current study the focus is to investigate the effect of a soft storey for multi-storied high rise building with different models having identical building plan. Soft storey level is altered at different floors in different models & equivalent static analysis is carried out using ETABS software. This study has been undertaken to study of different location on the seismic behavior of multi-story building. linear dynamic analysis (Response spectrum analysis) in ETABs software is carried out. Different seismic parameters like time period, story shear, and story displacement are checked out. It can be concluded that fundamental natural period of bare frame not only depends on building height but also on span length and the stiffness of building which are not quantified in the Codal expressions

Kiran Tidke - 2016 In this paper effect of masonry infill wall on building is studied. Dynamic analysis of building with different arrangement is carried out. For analysis G+7 R.C. frame building is modelled. The width of strut is calculated by equivalent diagonal strut method. Analysis is carried by SAP2000 software. Base shear, max. storey drift, Displacement is calculated and compared for all models. Some of main conclusion as follows, RC frame with masonry infill with and without soft storey is having highest value of base shear than bare frame. The presence of infill wall can affect the seismic behavior of frame structure to large extent, and the infill wall increases the strength of stiffness of structure.

Ashitosh C. Rajurkar - 2016 This paper report comprises of seismic analysis of a six storied R.C. building with symmetrical plan. Analysis is performed for Bare frame, Frame with infill wall. Building is analysed using Equivalent static method The building is modelled as a 3D space frame with six degrees of freedom at each node using the software STAADPro V8i.Results are obtained by comparing base shear and maximum displacement in X & Z directions. So, it is concluded that the consideration of stiffness of masonry infill greatly increases the stiffness of the structure and therefore reduces the natural period and consequently increase the response acceleration and therefore the seismic forces (i.e. base shear and correspondingly the lateral forces at each storey.

Akshay S. Paidalwar - 2017 This study investigates the soft storey behavior due to lack of infill at ground floor storey and existence of this case by means of linear static and nonlinear static analysis for midrise reinforced concrete building. Soft storey behavior due to change in infill's amount is evaluated in view of the displacement, drift demand and structural behavior. It is Found That Stiffness of the structure is an important factor in case of OGS type building,in the present study infill can improve stiffness of structure but in to some extent, that is not enough to save structure against seismic effect. Problem of OGS buildings cannot be identified properly through elastic analysis as the stiffness of OGS building and Bare-frame building are almost same.

Piyush Tiwari - 2015 The objective of this study is to check the applicability of multiplication factor of 2.5 and to study the effect of infill strength and stiffness in seismic analysis of OGS buildings. Three Different models of existing RC framed building with open ground storey located in Seismic Zone V is considered for the study using commercial Etabs Software. Infill Stiffness with openings was modelled using a Diagonal Strut approach. Linear and Nonlinear analysis is carried out for these models and results were compared. It is found that Seismic analysis of bare frame structure leads to under estimation of base shear. Under estimation of base shear leads to collapse of structure during earthquake shaking. Therefore, it is important to consider the infill walls in the seismic analysis of structure.

Kevin Shah - 2017 The study includes the calculations of storey shear, storey drift and storey displacement of G+14 building which is situated in zone-5 with different irregularities. Irregularities are crucial in studying the seismic behavior of building. The irregularities considered are mass irregularity and vertical geometric irregularity. The mass irregularity has first floor without masonry wall and rest of floor with infill masonry wall i.e. soft storey and vertical geometric irregularity has uneven geometry in vertical position & shape of building. In very severe earthquake zone, structure fail due to high lateral loads in this project lateral loads are considered in both direction (EQX & EQY). The modelling and calculations of building are done using ETABS. It is found that Top story displacement is maximum for vertically irregular of structure and minimum for symmetric infill wall structure

N. Anvesh - 2015 In this present work analysis for G+10 Reinforced cement concrete building having mass irregularity in 3rd and 6th floors and building without mass irregularity are analysed. This paper highlights the effects on floor which has different loads (mass irregularity) in multistorey building. From the results, it was observed that Beams in refuse area are expected to have more shear force and bending moment. Also, it was observed that Deflection is more in case of refuse area beams of mass irregular building when compared to building without mass irregularity and there is an increase of 67% in the moments of mass irregular buildings than buildings without mass irregularity.

III. METHODOLOGY

For easy work flow during progress of work, whole work is divided into various parts which are in detail as discussed below

General introduction focuses on the background of this dissertation. It shows that detailed investigation and study has to be done for soft storey behavior and soft storey design.

Literature review deals with the summary of the technical papers published till date and the data regarding the dissertation in the same. It also focuses on the extensive research significances carried out up till now regarding the dissertation as well as the scope for further studies.

A. Modelling of Building

Here the study is carried out for the behavior of G+10 storied R.C buildings with Rectangular shaped plan of soft storeys at different levels. Floor height provided as 3.4m and also properties are defined for the irregular R.C building modelled in STAAD. Pro V8i software, Here twelve models are created in which soft storey is provided at ground, fifth and eleventh storey in all four seismic zones.

B. Building Plan and Dimension Details

The following are the specification of G+ 10 storied irregular RC building located in seismic zone III. Here the rectangular shaped building is selected. For modelling in STAAD Pro.V8i software the first step is to specify nodal co-ordinate. Then beams, columns and plate elements to be modeled and assign the properties for beams, columns and the plates. After assigning the sectional property to the member it is important to assign it with member properties. Material properties include modulus of elasticity, poison's ratio, weight density, thermal coefficient, damping ratio and shear modulus.

C. Load Formulation

As it is well known that while analyzing it is advised to go for various load combinations as they are more severe while studying the behaviors of building under earthquake. In the present work Static gravity loads were taken from IS 875 part 1 and part 2 and their combinations were as per 18 456:2000 while earthquake loads and their combinations were taken as per IS 1893 (part 1) 2002

D. Analysis

The twelve-dimensional reinforced concrete structures with G+10 storied building with soft storeys at different level are analysed using STAAD Pro software. The main code for the analysis is IS 1893 (Part 1) 2002 and provide the outline for calculating seismic design force. The method of analysis used is Equivalent static analysis to calculate displacement, base shear and storey drift. Among the different types of analysis, seismic analysis comes forward because of its optimal accuracy, efficiency and ease of use. Seismic analysis is done to evaluate the maximum shear force, bending moment and the dynamic results in the form of storey drift and lateral displacements. Equivalent Static Analysis defines a series of forces acting on a building to represent the effect of earthquake ground motion.

IV. CASE CONSIDERATION AND MODELLING

The various building parameters and material constants along with the detailed description about case considered as per tables given below

A. Material Constants

Table 4.1 Material Constants

Material	Concrete	Steel
Grade	M 40	Fe 500
Mass Density	2549.3	7849
Unit Weight	25	76.97
Modulus of Elasticity	25,000,000	20,000,000
Poisson's Ratio	0.15	0.3

B. Building Parameters

Table 4.2 Building Parameters

Parameter	Value
Live load	3 KN/m2
Live load at upper soft storey's	5.KN/m2

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Density of concrete	25 KN/m3
Thickness of slab	125 mm
Depth of beam	380 mm
Width of beam	230 mm
Dimension of column	300 x 450 mm
Thickness of outside wall	230 mm
Thickness of Parapet wall (1m)	100 mm
Height of floor	3.40 m
Damping ratio	5%
Earthquake zone	II/III/IV/V
Type of soil	II
Type of structure	Special moment resisting frame
Response reduction factor	5
Importance factor	1.5
Roof treatment	I KN/m2
Floor finishing	I KN/m2
Number of Storey's	11 (G+10)
Depth of Foundation	1.50 m

C. Model nomenclature

Table 4.3 Model Nomenclature

Model Description	Label
Soft Storey at ground floor in Zone-II	S1
Soft Storey at fifth floor in Zone-II	S2
Soft Storey at eleventh floor in Zone-II	S3
Soft Storey at ground floor in Zone-III	S4
Soft Storey at fifth floor in Zone-III	S5
Soft Storey at eleventh floor in Zone-III	S6

D. Plan of model

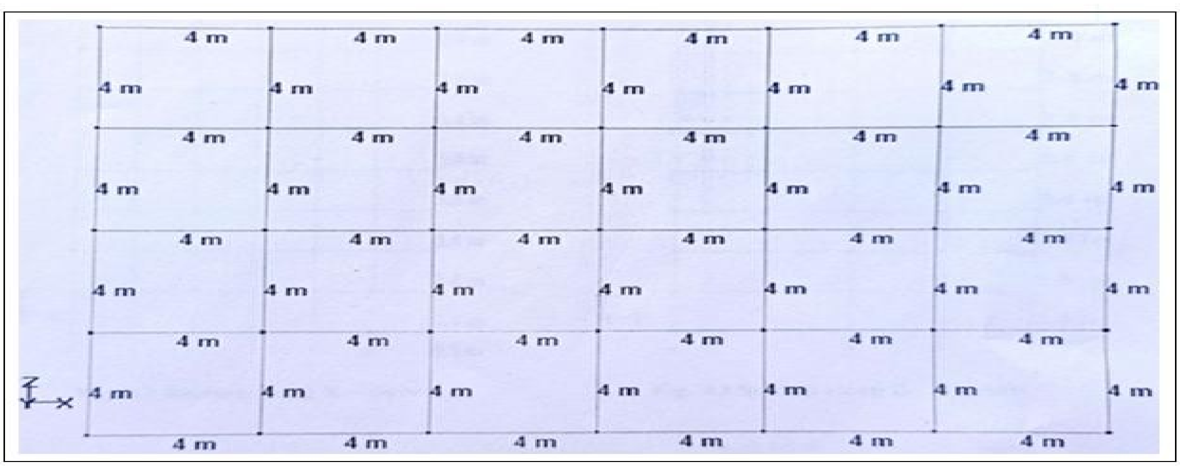

Fig. 4.1 Plan of model

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Volume 13 Issue IV Apr 2025- Available at www.ijraset.com

E. Cross section along X and Z – axis

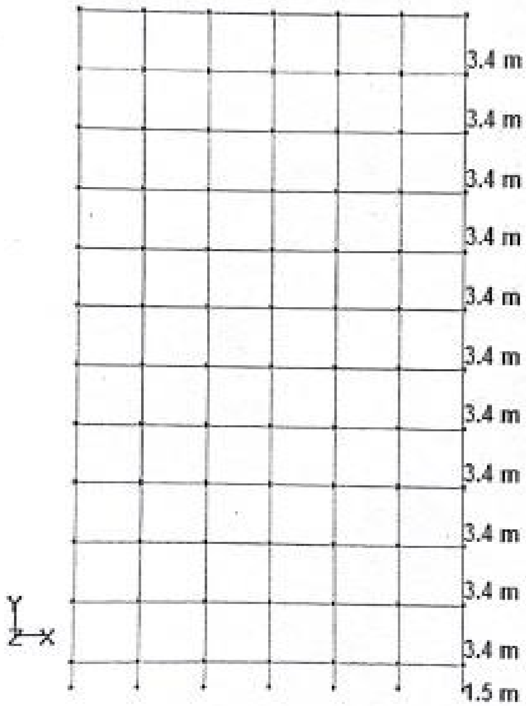


Fig. 4.2 Section along X – direction

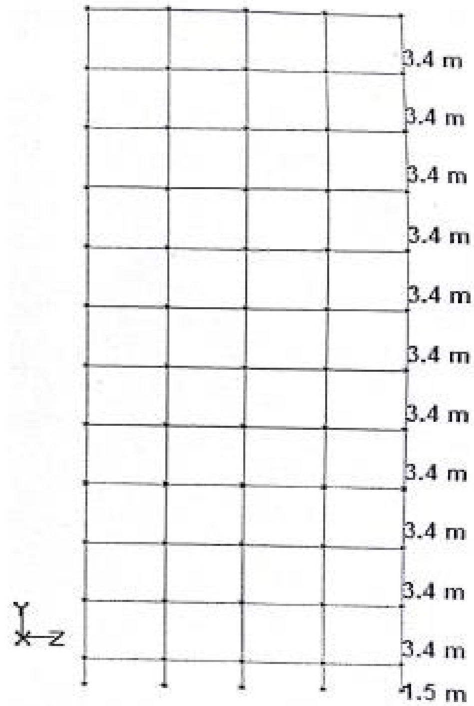


Fig. 4.3 Section along Z - direction

F. Support Condition for model

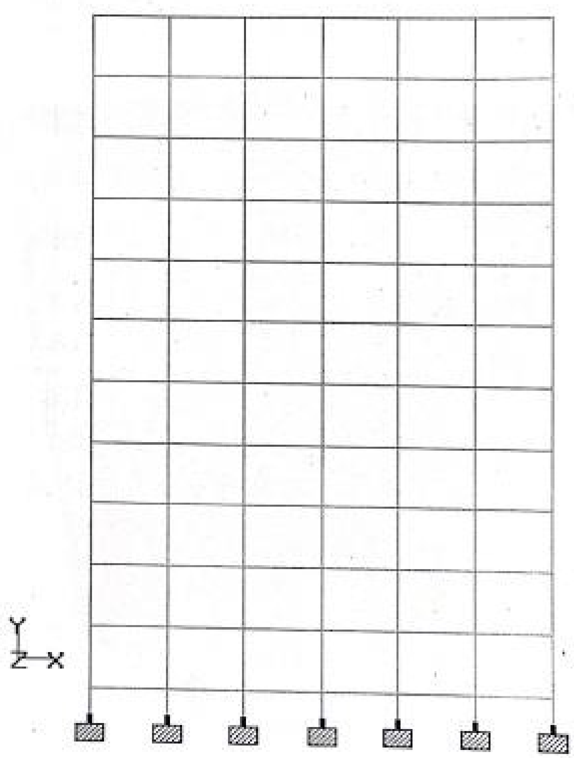


Fig. 4.4 Fixed Support at base

G. 3D view of model

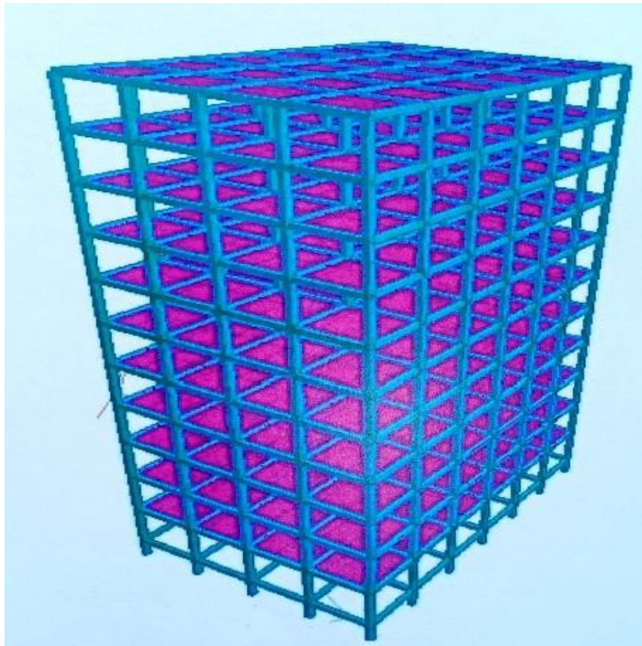


Fig 4.5 3D view with slab

V. RESULTS AND DISCUSSIONS

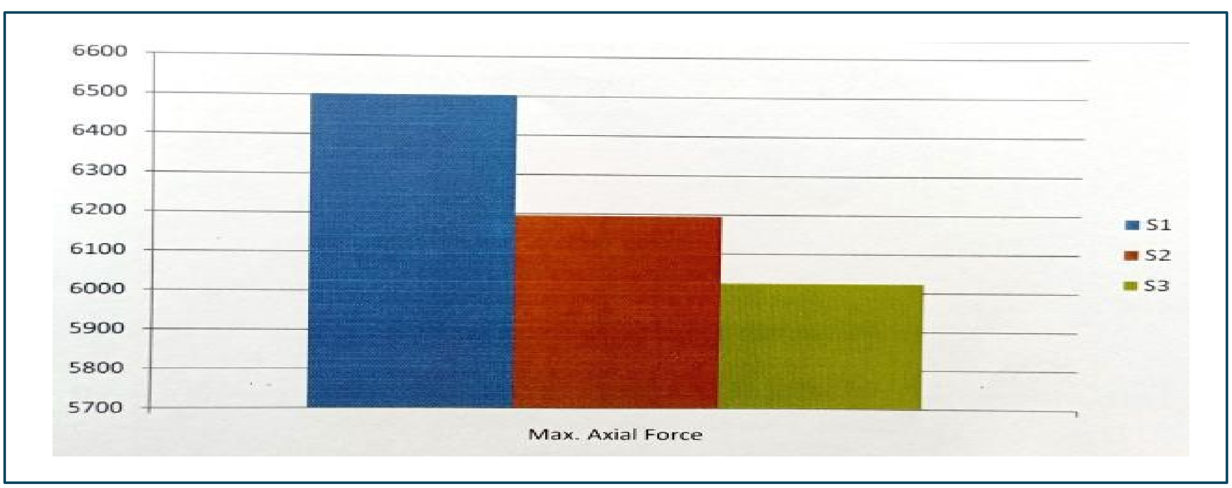
A. Result Comparison for all models in Zone-II

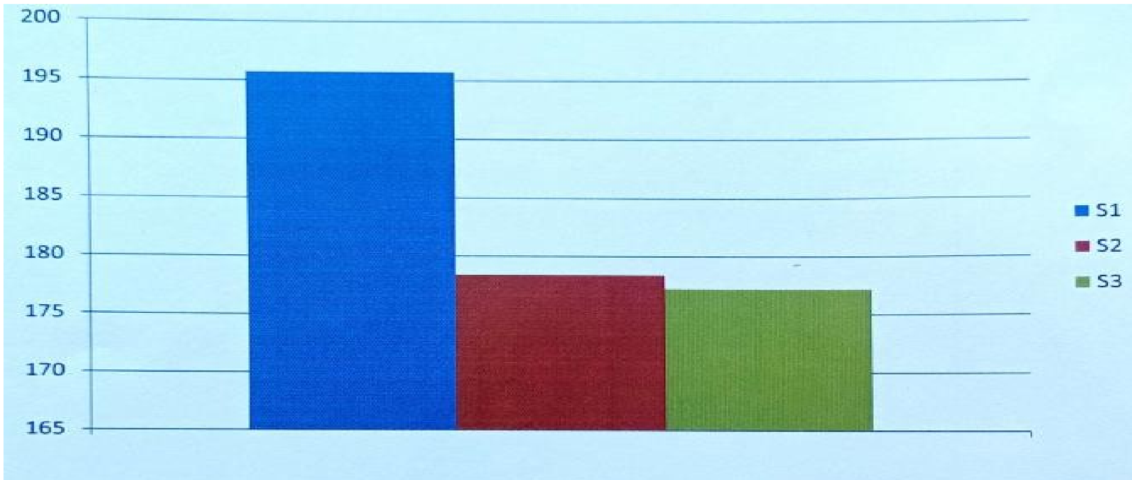
1) Comparison for Max. Axial Force, Moment and Displacement

Table 5.1 Axial Force, Moment and Displacement Comparison for S1, S2, S3

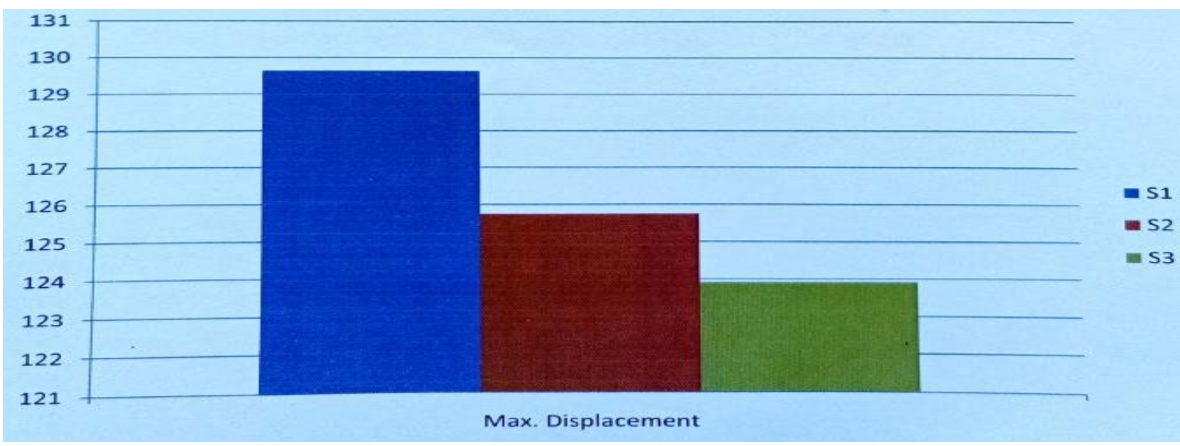
Sr. No.	odel No	xial Force (KN)	Max. Moment (KN.m)	Max. Displacement (mm)
1	S1	6502.86	195.72	129.64
2	S2	6194.90	178.39	125.74
3	S3	6024.46	177.22	123.92

Graph 5.1 Comparison of Axial forces for model S1, S2, S3





Graph 5.2 Comparison of Maximum Moment for model S1, S2, S3



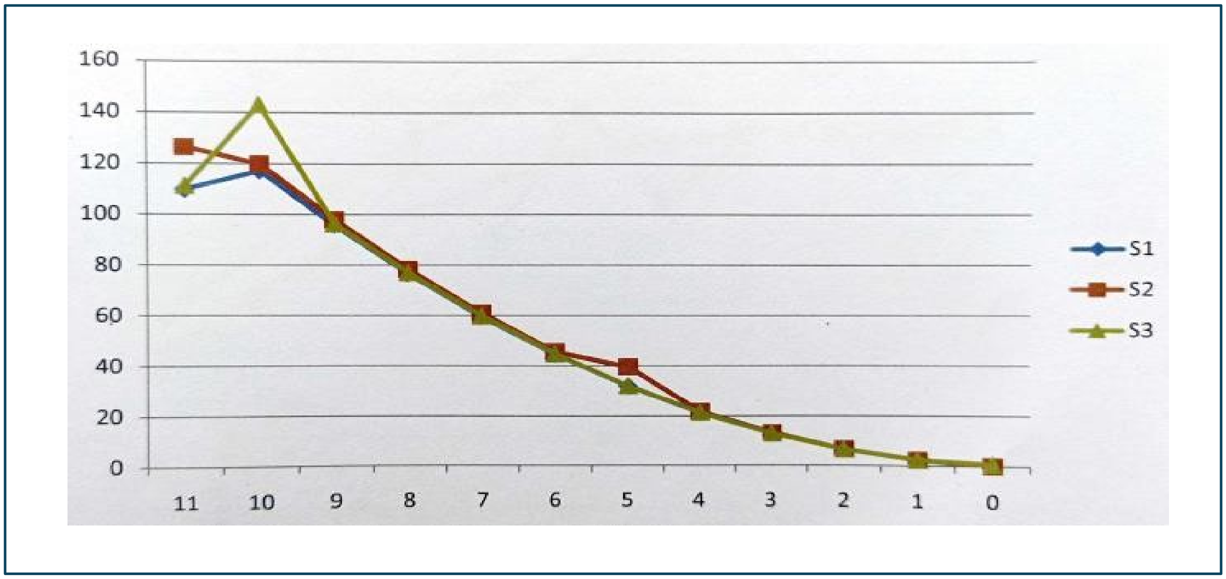
Graph 5.3 Comparison of Maximum Displacement for model S1, S2, S3

2) Comparison for Base Shear Distribution

Table 5.2 Storey Shear Distribution Comparison for S1, S2, S3

Sr. No.	Height	Storey Level	Model		
			S1	S2	S3
1	37.40	11	109.80	126.45	111.29
2	34.00	10	117.15	119.83	143.13
3	30.60	9	095.79	97.97	96.32
4	27.20	8	076.57	78.32	77.00
5	23.80	7	059.50	60.86	59.83
6	20.40	6	044.58	45.60	44.83
7	17.00	5	031.80	39.54	31.99
8	13.60	4	021.20	21.68	21.31

9	10.20	3	012.73	13.02	12.80
10	6.80	2	006.40	6.55	6.44
11	3.40	1	002.23	2.28	2.24
12	0.00	0	000.07	0.076	0.75
Total Base Shear			577.80	612.17	607.26



Graph 5.4 Comparison of Storey Shear Distribution for model S1, S2, S3

3) Comparison for Storey Drift

Table 5.3 Storey displacement Comparison for model S1, S2, S3

Sr. No.	Height	Node No.	Model		
			S1	S2	S3
1	37.40	427	1.77	1.26	1.24
2	34.00	392	2.71	2.09	2.03
3	30.60	357	3.68	2.77	2.75
4	27.20	322	4.47	3.37	4.07
5	23.80	287	5.10	3.81	3.02
6	20.40	252	5.56	4.17	4.91
7	17.00	217	5.88	4.39	3.49
8	13.60	182	6.08	4.55	4.45
9	10.20	147	6.12	4.65	4.5
10	6.80	112	5.80	4.54	4.40
11	3.40	77	5.51	4.87	4.52

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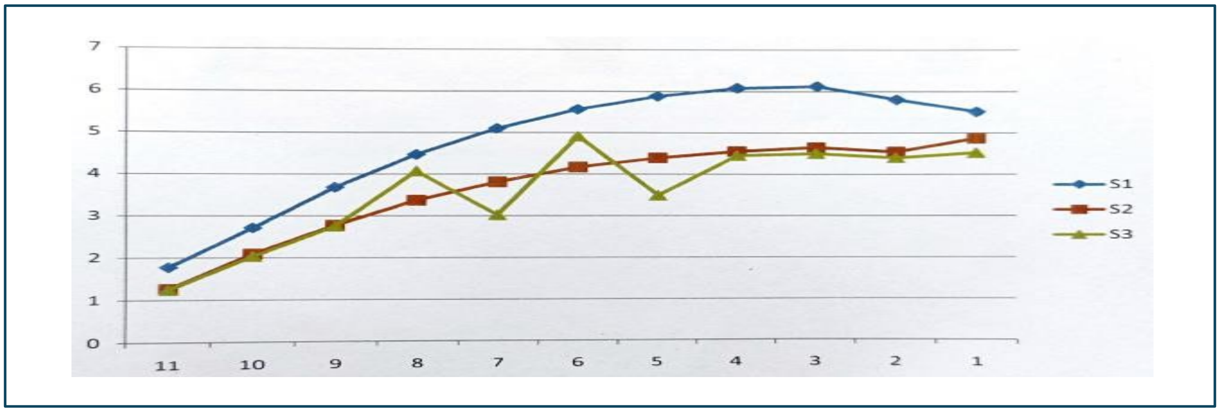
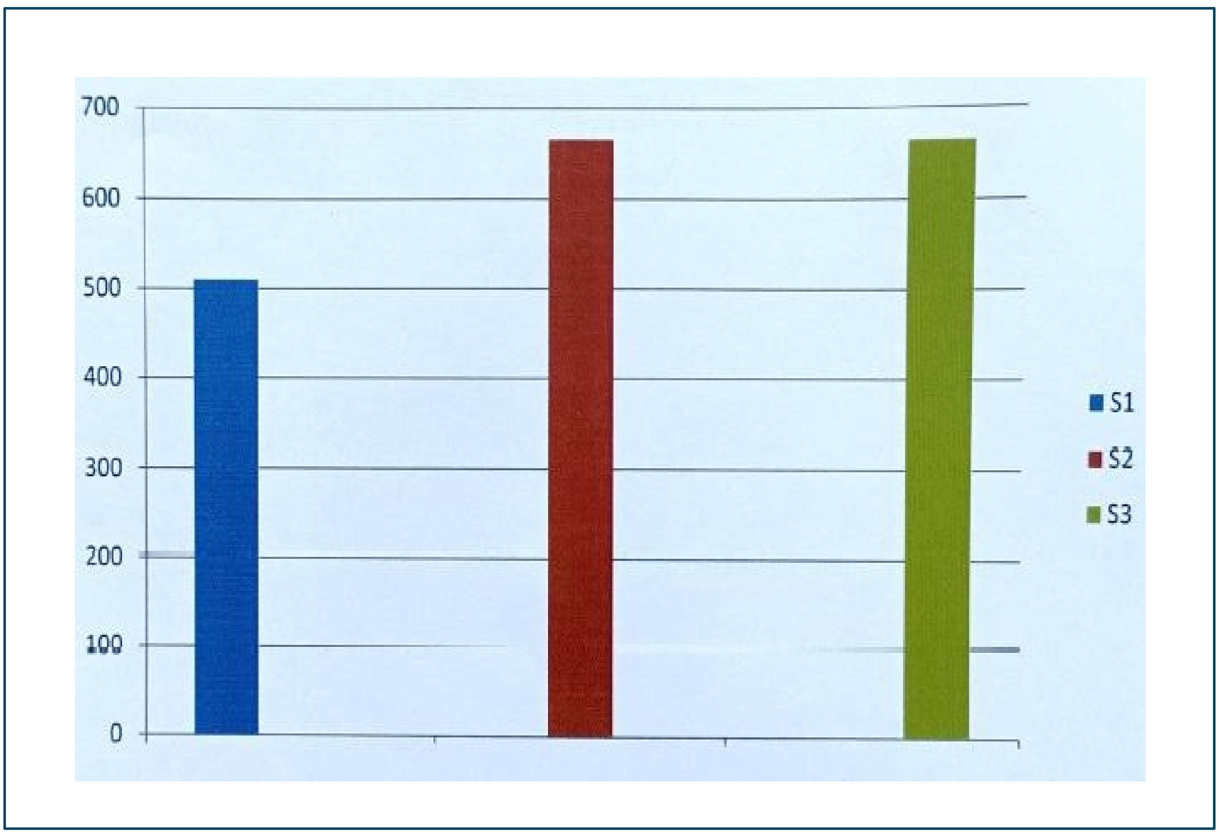


Graph 5.5 Storey displacement Comparison for model S1, S2, S3

4) *Reinforcement Comparison*

Table 5.4 Reinforcement Comparison for model S1, S2, S3

Sr. No.	Model	Quantity (KN)
01	S1	509.93
02	S2	665.87
03	S3	663.97



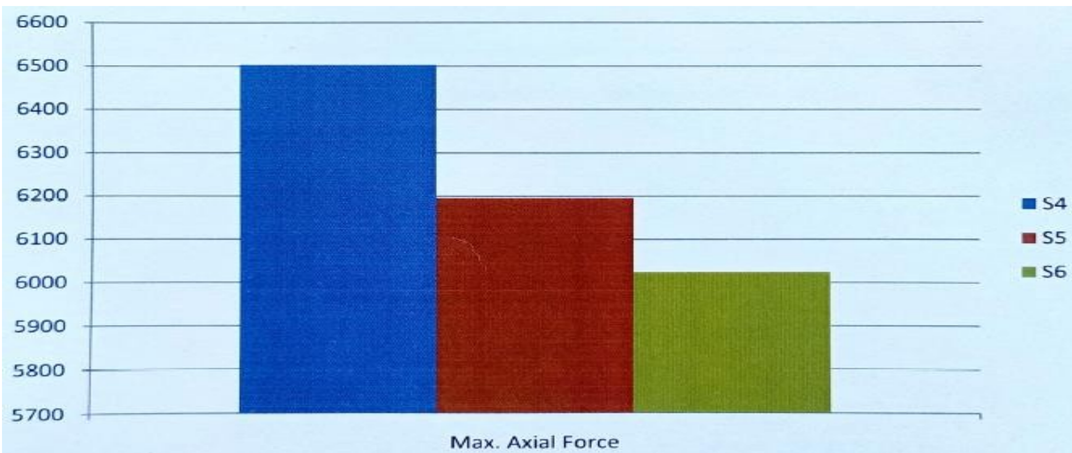
Graph 5.6 Reinforcement Comparison for model S1, S2, S3

B. Result Comparison for all models in Zone – III

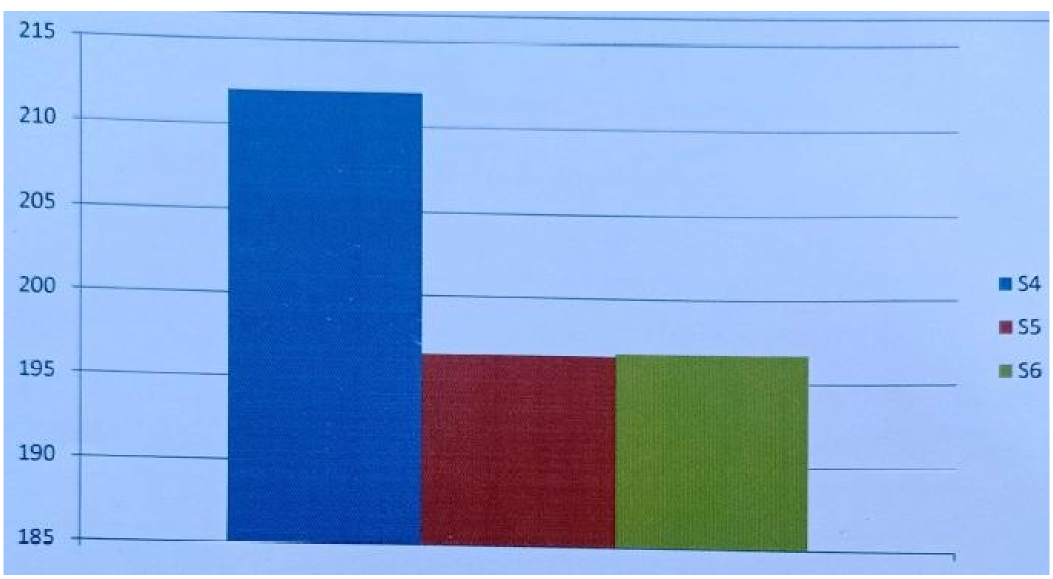
1) Comparison for Max. Axial Force, Moment and Displacement

Table 5.5 Axial Force, Moment and Displacement Comparison for model S4, S5, S6

Sr. No.	Model No.	Max. Axial Force (KN)	Max. Moment (KN.m)	Max. Displacement (mm)
01	S4	6502.86	212.03	144.93
02	S5	6194.90	196.53	134.72
03	S6	6024.46	196.72	132.31



Graph 5.7 Comparison of Axial forces for model S4, S5, S6



Graph 5.8 Comparison of Moments for model S4, S5, S6

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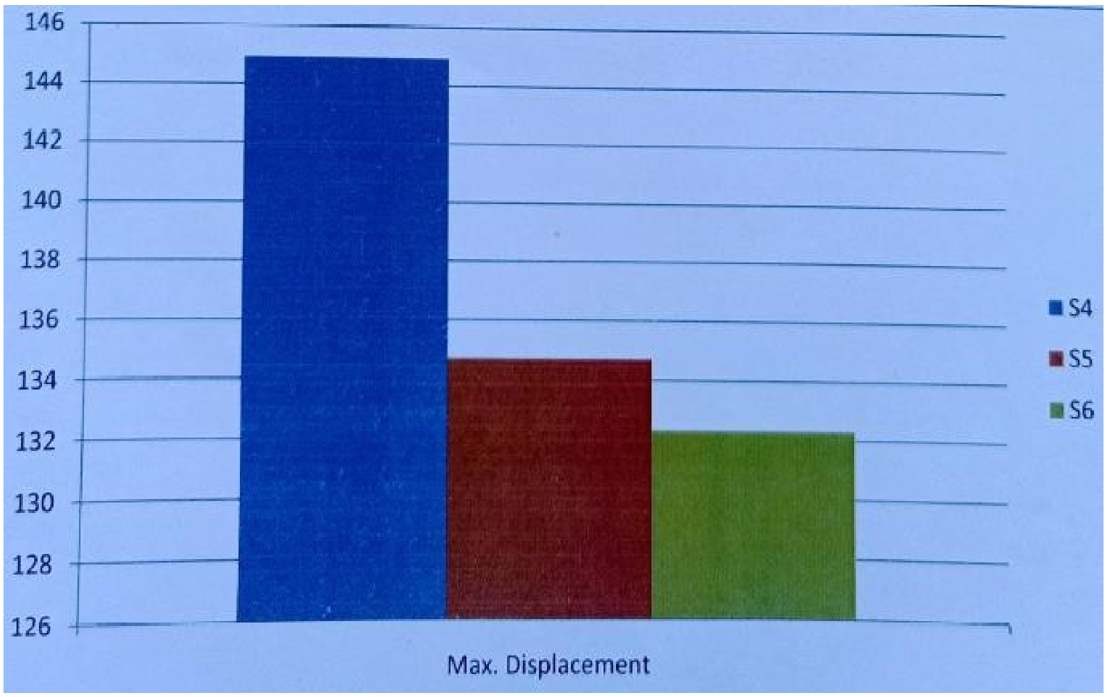

Graph 5.9 Comparison of Maximum Displacement for model S4, S5, S6

2) Comparison for Base Shear Distribution

Table 5.6 Storey Shear Distribution Comparison for S4, S5, S6

Sr. No.	Height	Storey Level	Model		
			S4	S5	S6
1	37.40	11	175.69	202.33	178.06
2	34.00	10	187.44	191.72	229.01
3	30.60	9	153.26	156.75	154.11
4	27.20	8	122.51	125.31	123.19
5	23.80	7	95.20	97.38	95.74
6	20.40	6	71.34	72.96	71.73
7	17.00	5	50.91	63.26	51.19
8	13.60	4	33.91	34.69	34.10
9	10.20	3	20.36	20.83	20.47
10	6.80	2	10.25	10.48	10.30
11	3.40	1	3.57	3.65	3.59
12	0.00	0	0.11	0.12	0.12
Total Base Shear			924.55	979.47	971.62

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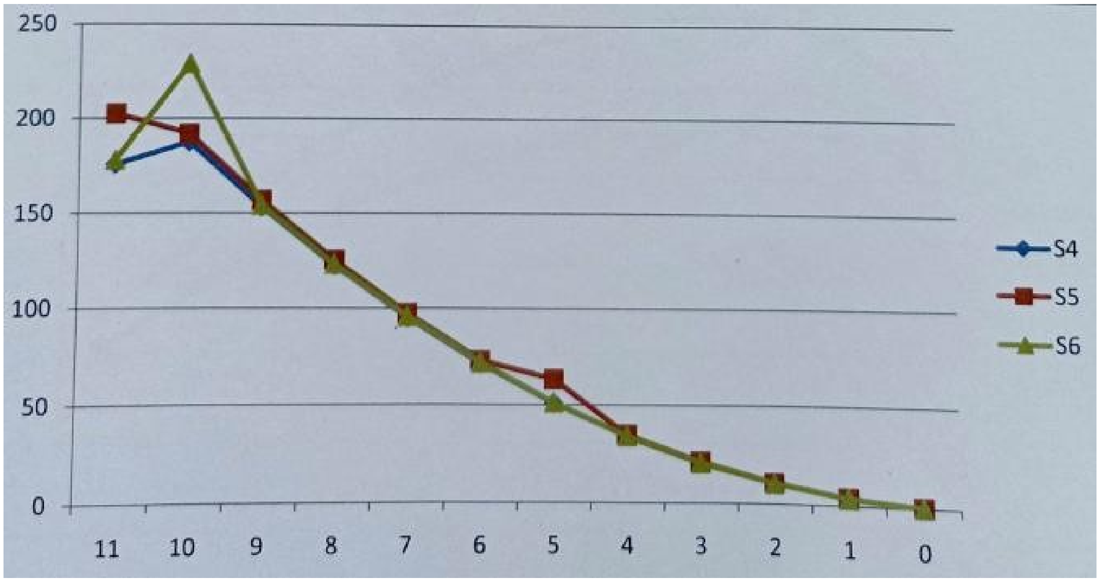
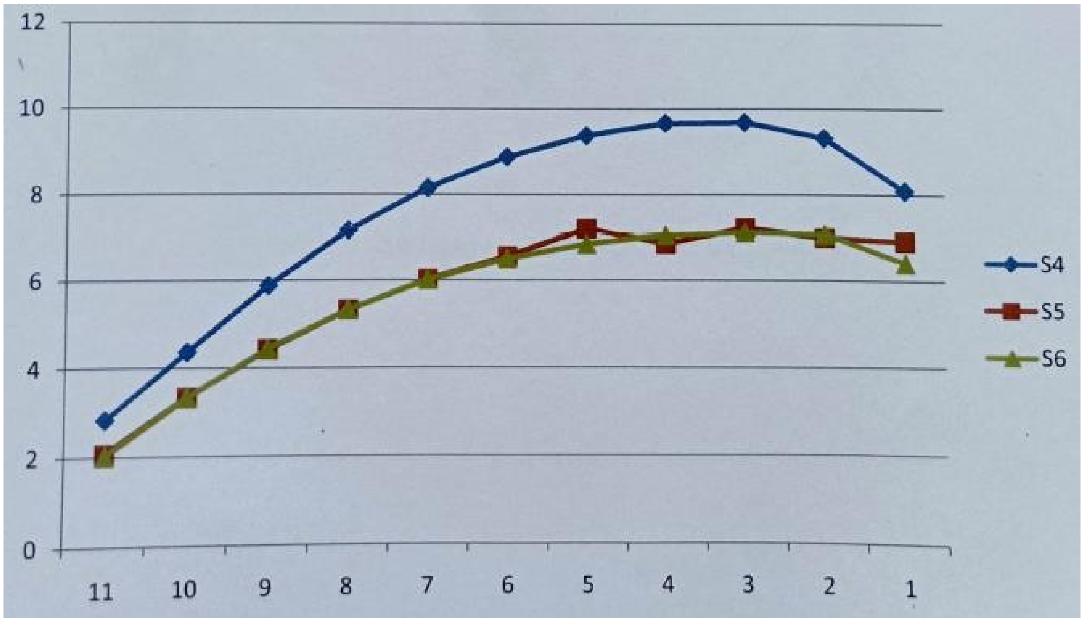


Graph 5.10 Comparison of Storey Shear Distribution for model S4, S5, S6

3) Comparison for Storey Drift

Table 5.7 Storey displacement Comparison for model S4, S5, S6

Sr. No.	Height	Node No.	Model		
			S4	S5	S6
1	37.40	427	2.83	2.07	2.02
2	34.00	392	4.36	3.33	3.33
3	30.60	357	5.88	4.42	4.44
4	27.20	322	7.15	5.32	5.33
5	23.80	287	8.14	6.02	6.01
6	20.40	252	8.87	6.55	6.50
7	17.00	217	9.37	7.19	6.83
8	13.60	182	9.66	6.84	7.04
9	10.20	147	9.68	7.21	7.11
10	6.80	112	9.31	6.98	7.07
11	3.40	77	8.08	6.90	6.41

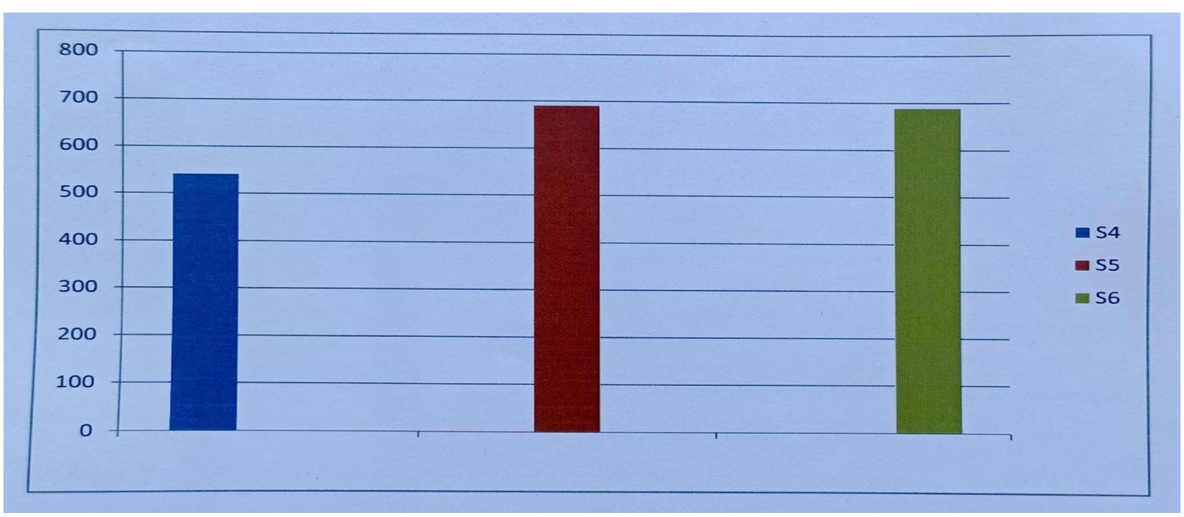


Graph 5.11 Storey displacement Comparison for model S4, S5, S6

4) *Reinforcement Comparison*

Table 5.8 Reinforcement Comparison for model S4, S5, S6

Sr. No.	Model	Quantity (KN)
01	S4	541.073
02	S5	689.659
03	S6	688.312



Graph 5.12 Reinforcement Comparison for model S4, S5, S6

VI. CONCULSIONS

1) Location of Soft storey effects seismic behavior of building in every zone from low to high seismicity.
2) As the location of soft storey goes upper it gives more stable stable structure compared to soft storey at ground level.
3) Soft storey at top level of structure is more stable than soft storey at middle part of structure.

VII. ACKNOWLEDGMENT

It gives me great pleasure on bringing out the report entitled.

"*Effect of soft storey on Multi-storey building*"

No undertaking of the magnitude involved in the preparation of this project can be accomplished alone. Many have contributed till the successful acknowledge the assistance of the following individuals and would like to thank each one of them.

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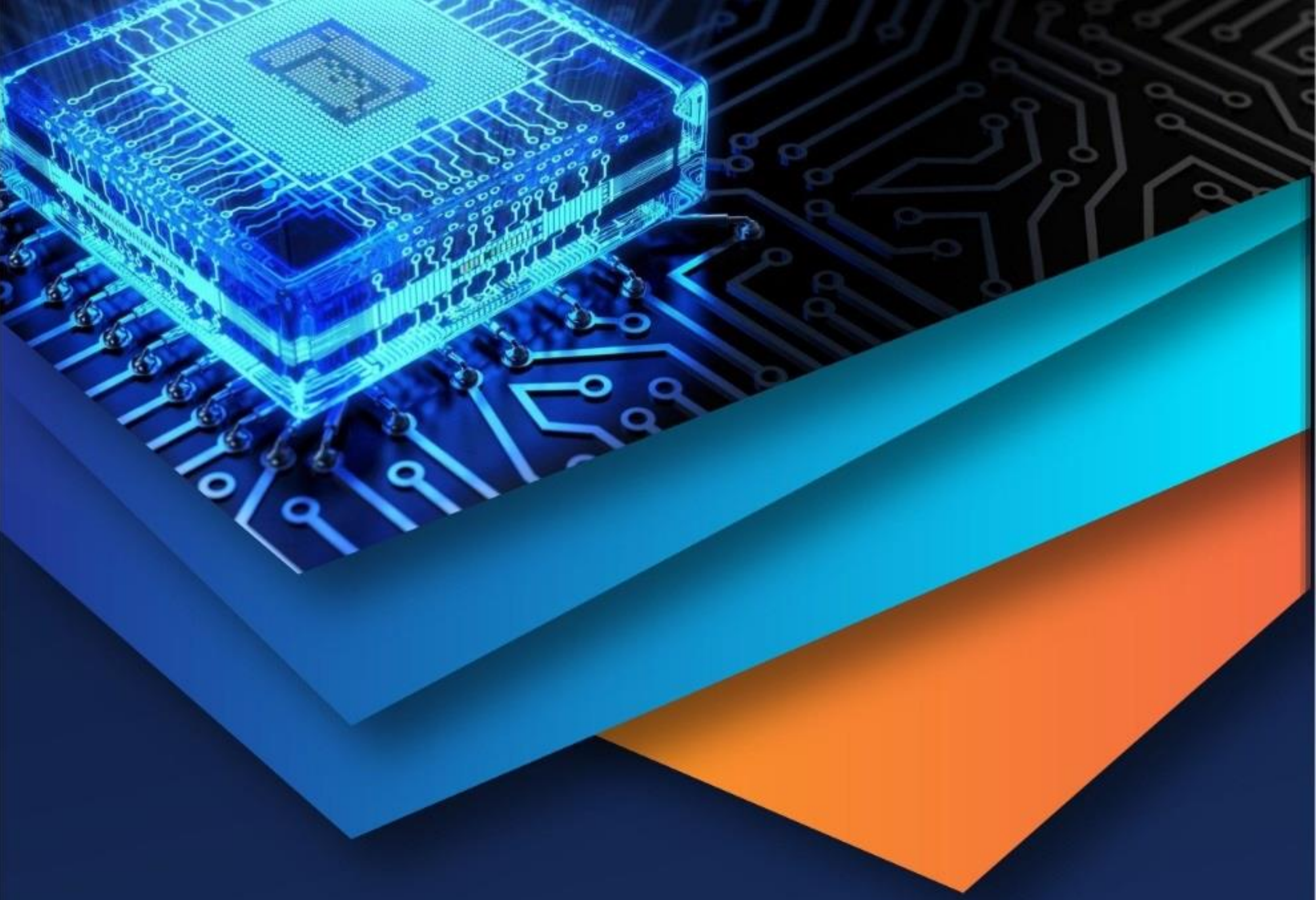

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